

# Horizon 2061

From overarching science goal  
to specific science objectives

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Horizon 2061 Synthesis workshop

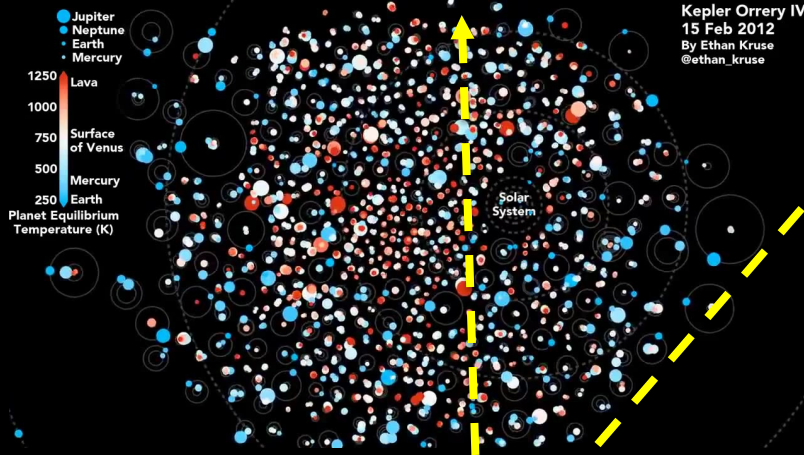
September 11th, 2019

# Planetary Systems

## A new class of astrophysical object

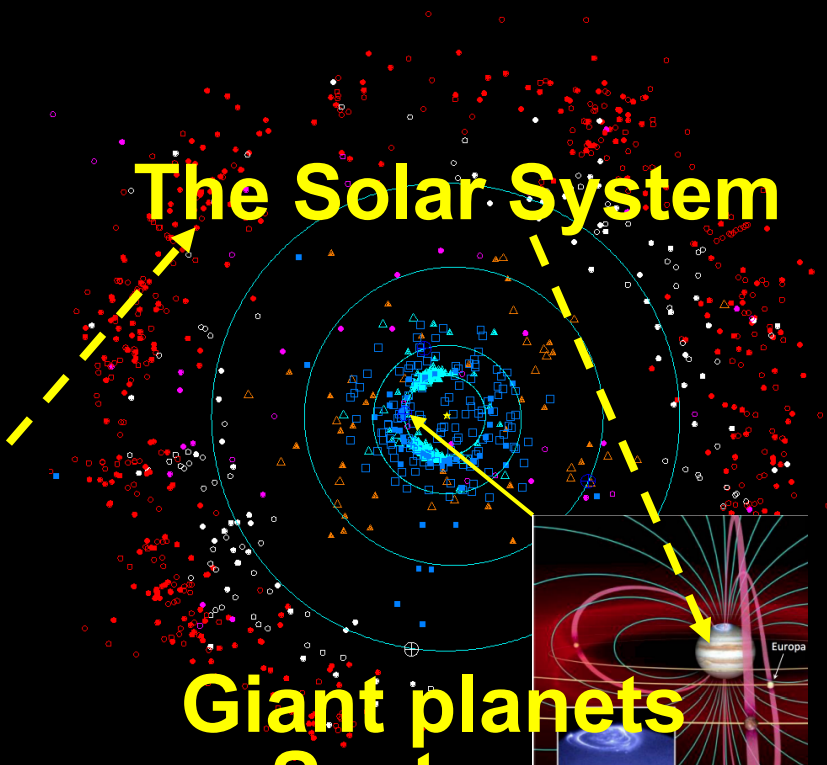
TEMPORAL EVOLUTION

### Extrasolar Planets Systems

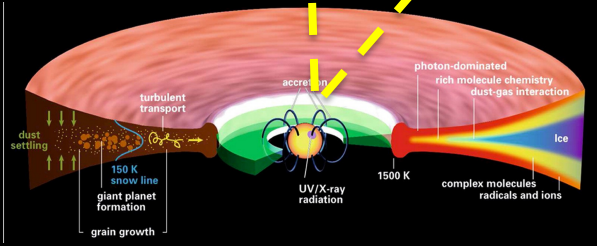


Kepler Orrery IV  
15 Feb 2012  
By Ethan Kruse  
@ethan\_kruse

### The Solar System



### Giant planets Systems



### Circumstellar disks

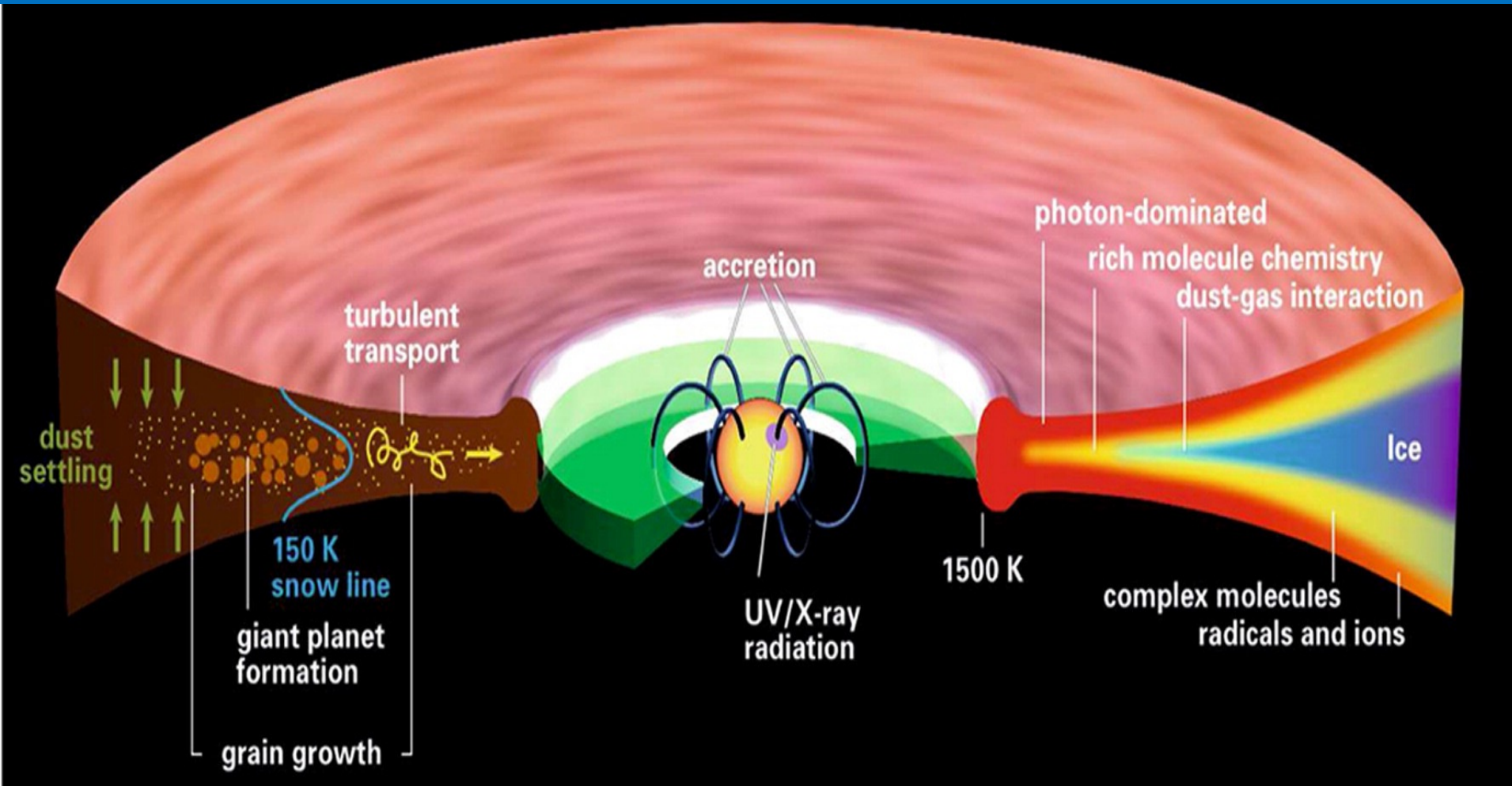
IN SITU MEASUREMENTS

REMOTE SENSING (ASTRONOMICAL OBSERVATIONS)

# Planets and stars nurseries



# Looking inside the “Planet Factory”

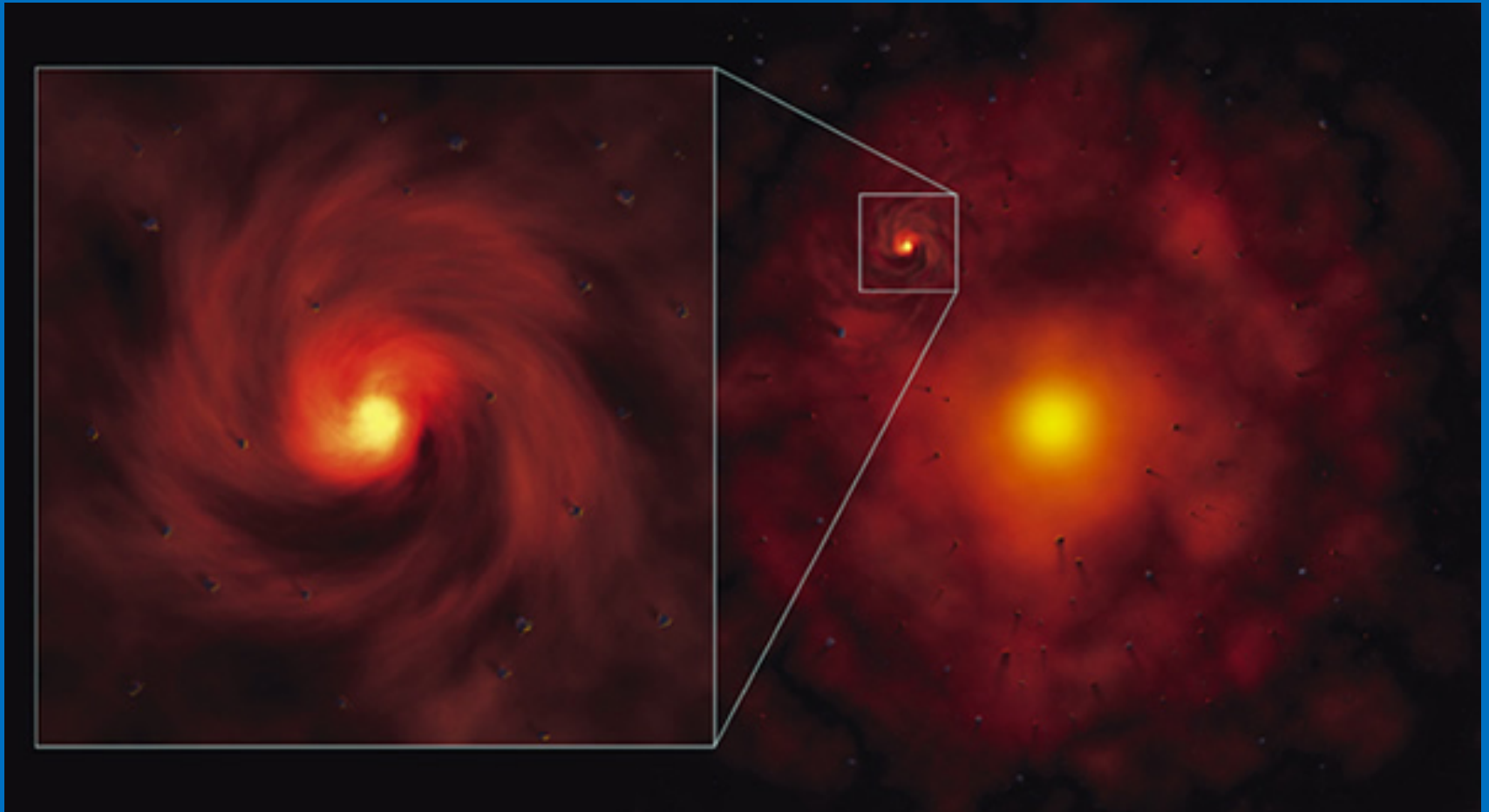


(courtesy of Henning and Semenov)

# GIANT PLANETS SYSTEMS

## ORIGINS AND FORMATION

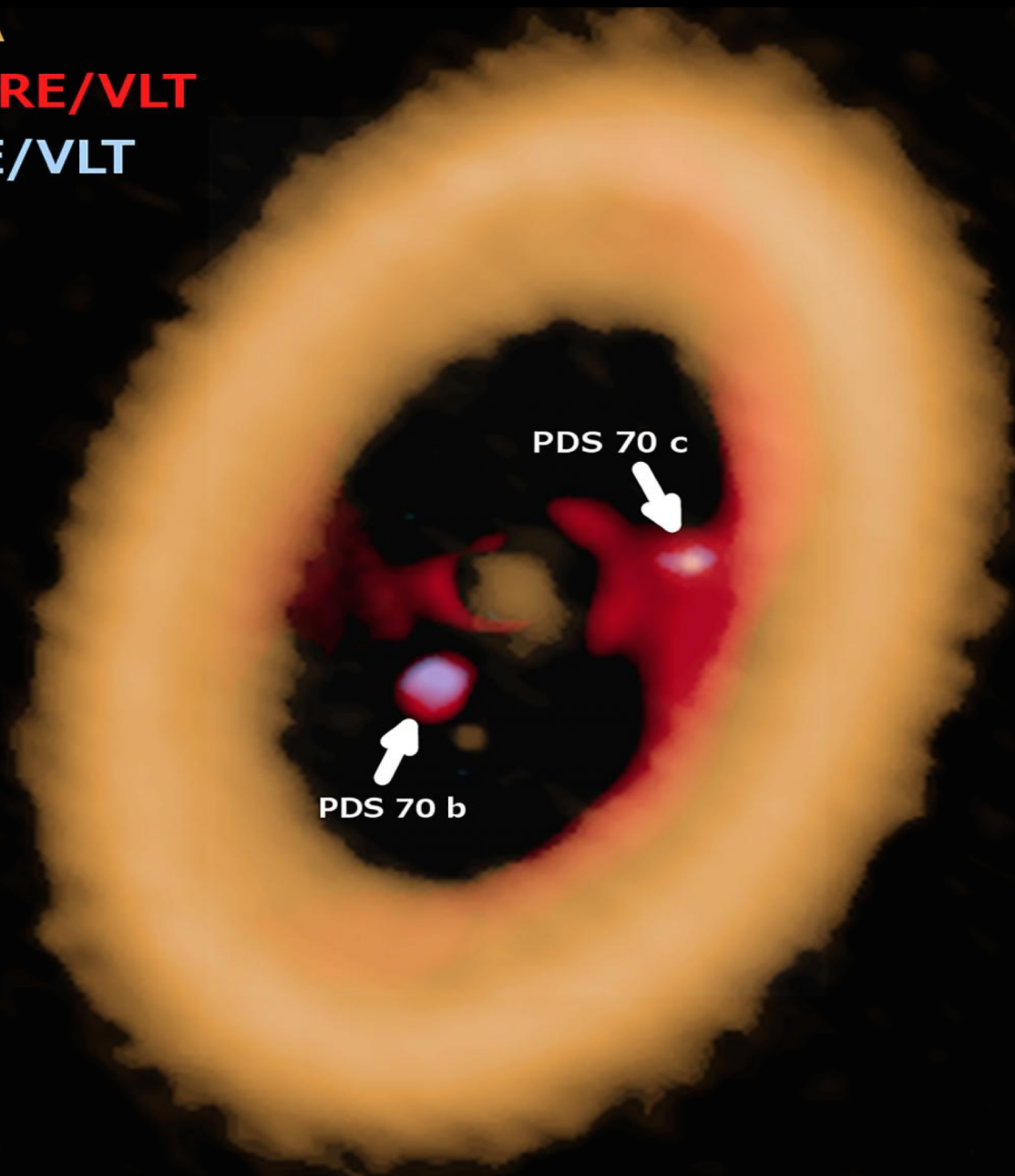
sub-nebulae in the Solar Nebula ?



**ALMA**

**SPHERE/VLT**

**MUSE/VLT**



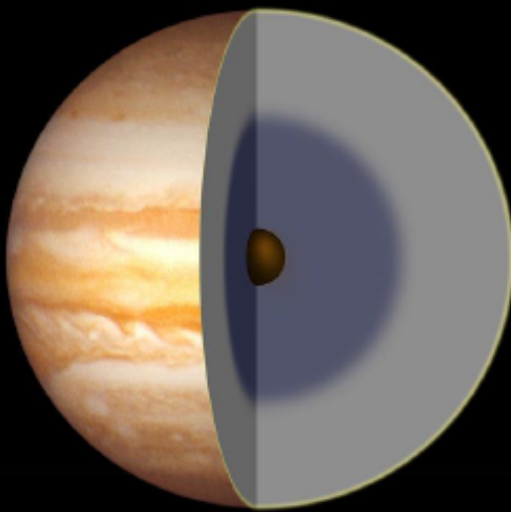
PDS 70 c

PDS 70 b

# DIVERSITY OF PLANETS

## Gas Giants

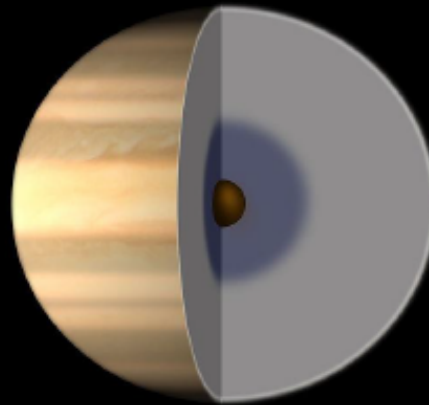
## Ice Giants



JUPITER

Satellites: 67

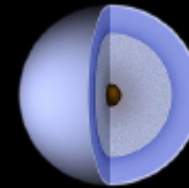
- Molecular hydrogen
- Metallic hydrogen



SATURN

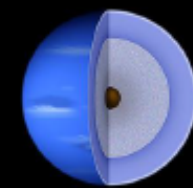
62

- Hydrogen, helium, methane gas
- Mantle (water, ammonia, methane ices)



URANUS

27

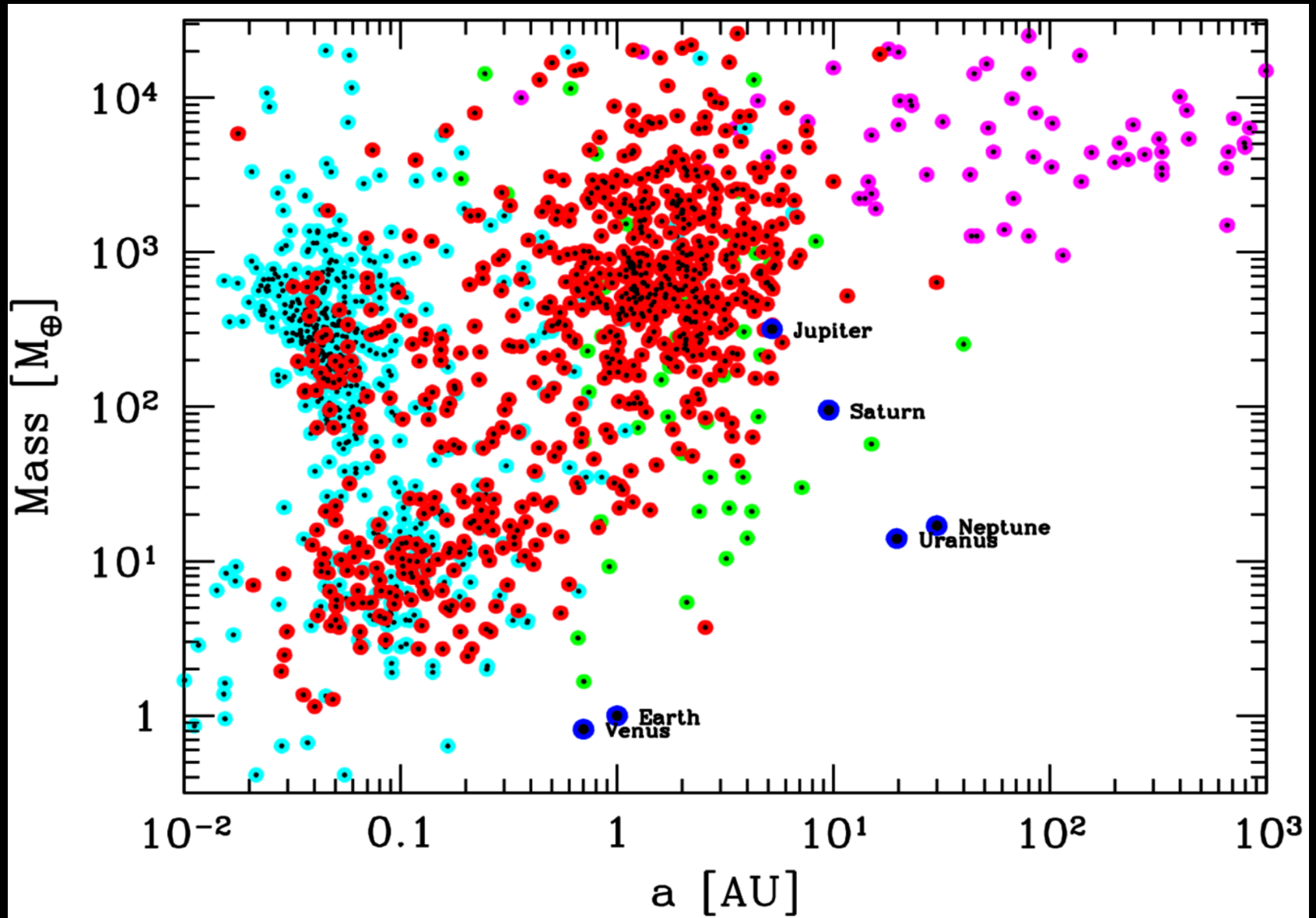


NEPTUNE

14

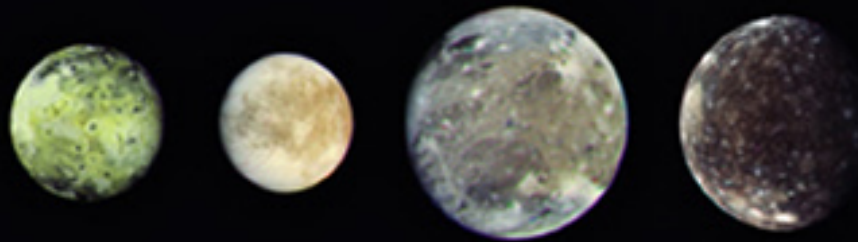
- Core (rock, ice)

# DIVERSITY OF PLANETS !





Jupiter



Saturn



Uranus



Neptune



# Diversity of satellites



Mercury



Moon

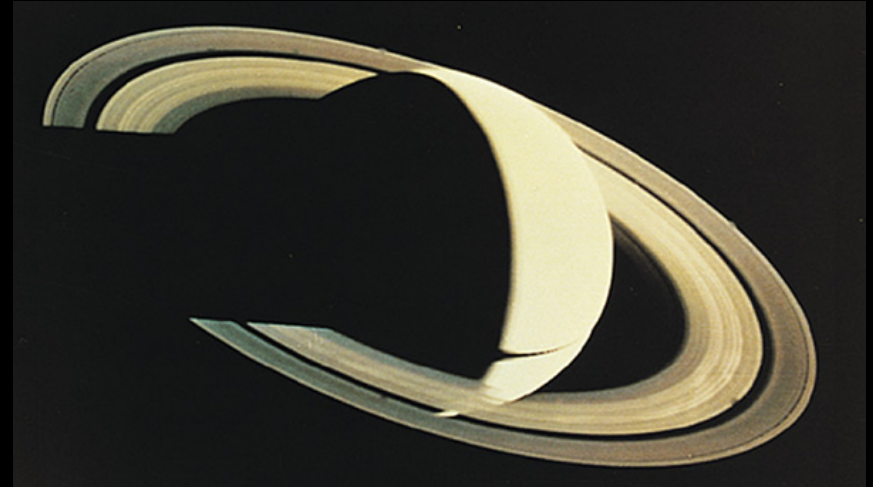


Pluto

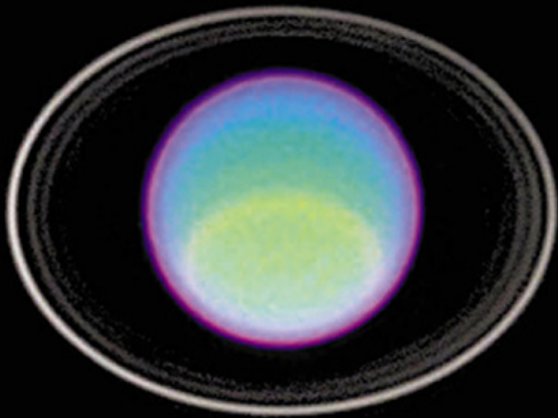
# Diversity of rings !



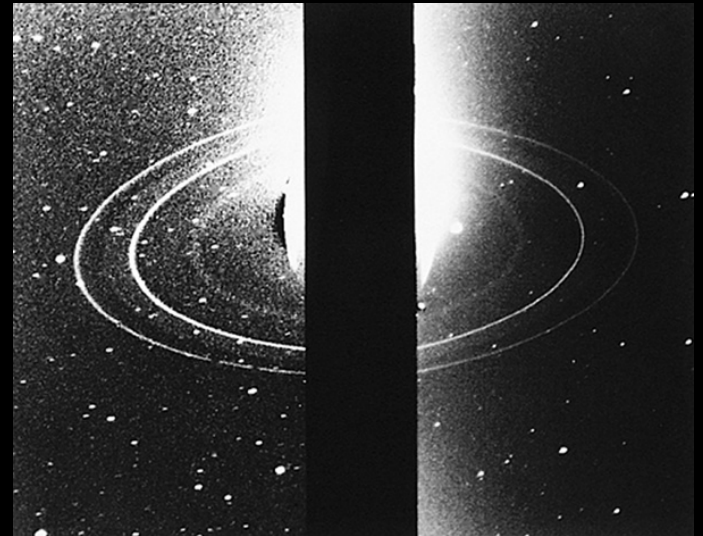
Jupiter



Saturn



Uranus



Neptune

# How do planetary systems work?

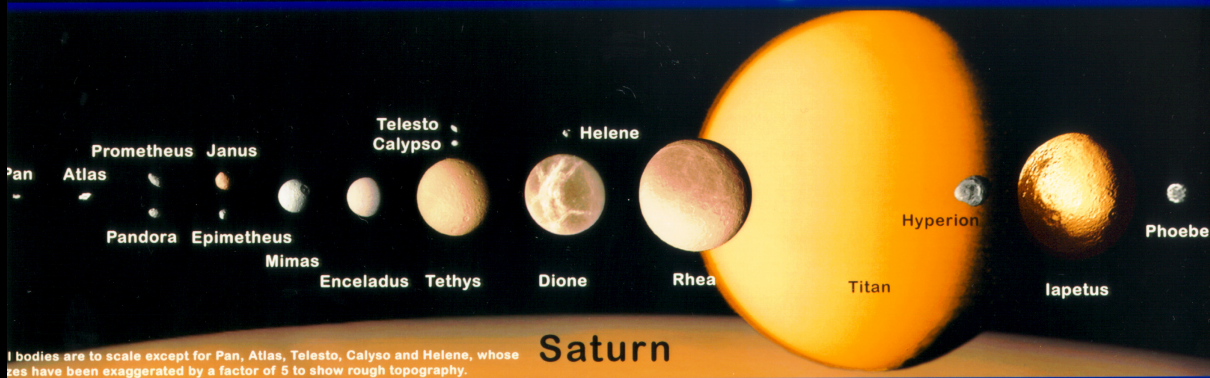
## Gravitational coupling

operates between planets or satellites, rings, small bodies and/or debris disks, gas and dust clouds and rings and one (or several) central object(s)

## Electrodynamic coupling

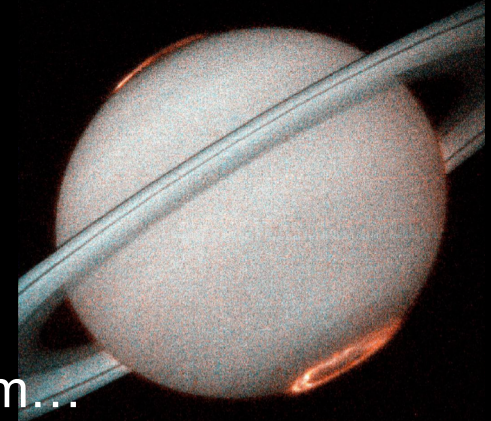
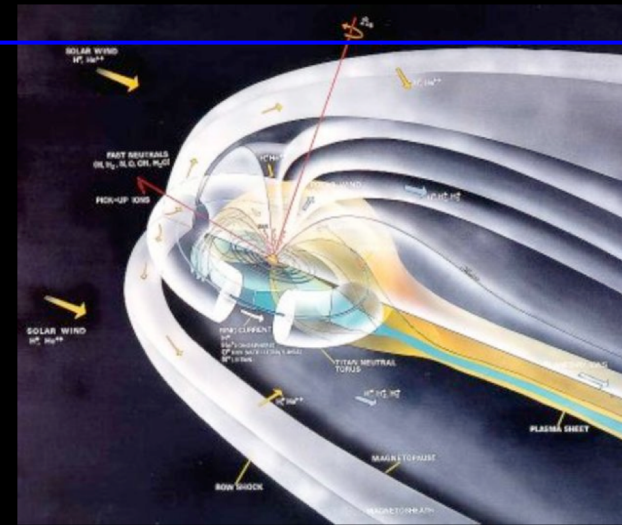
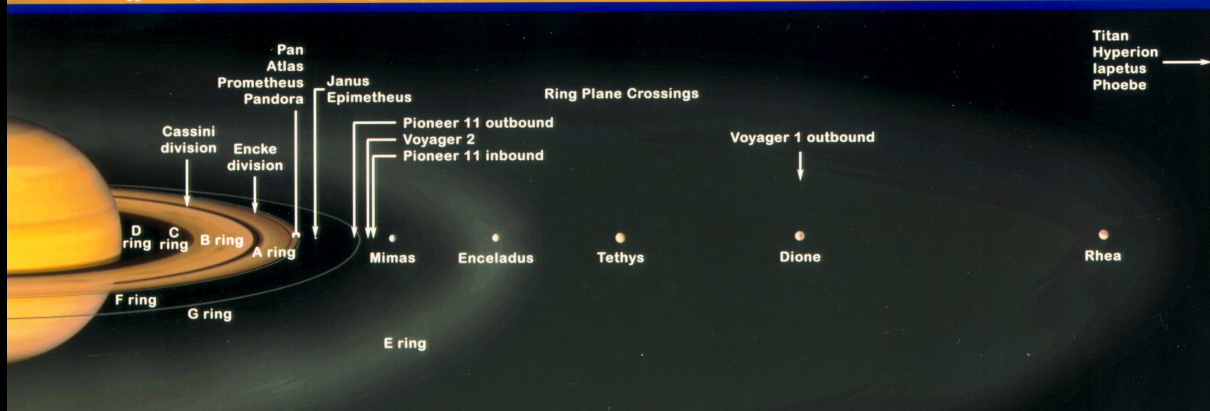
maintains and populates a magnetosphere, drives aurorae, provides energy sources to the planetary environment and regulates the interaction with stellar output and activity

### Saturn's Satellites and Ring Structure



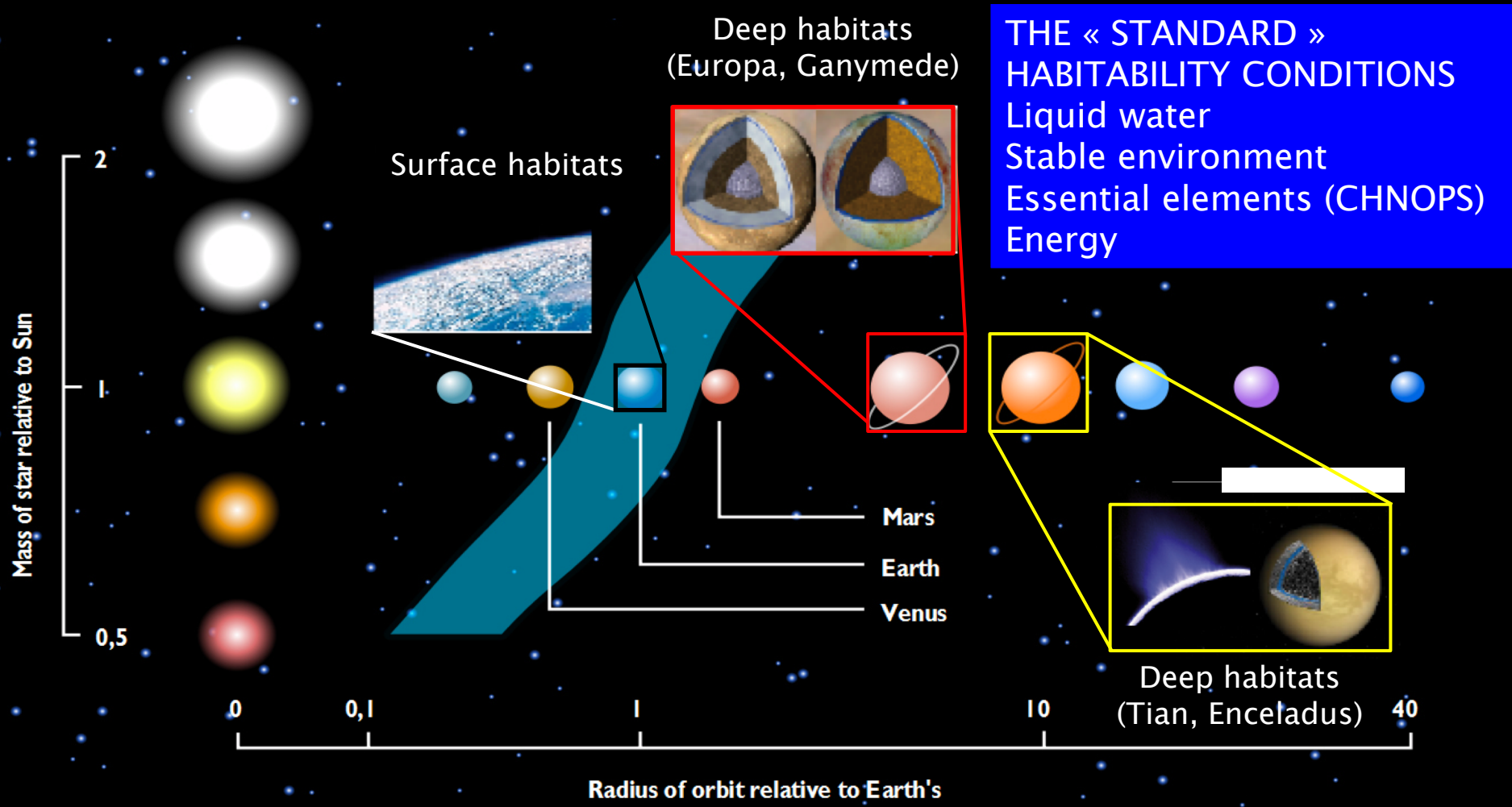
Small bodies are to scale except for Pan, Atlas, Telesto, Calypso and Helene, whose sizes have been exaggerated by a factor of 5 to show rough topography.

Saturn



+ collisions, phase changes, chemical reactions, volcanism...

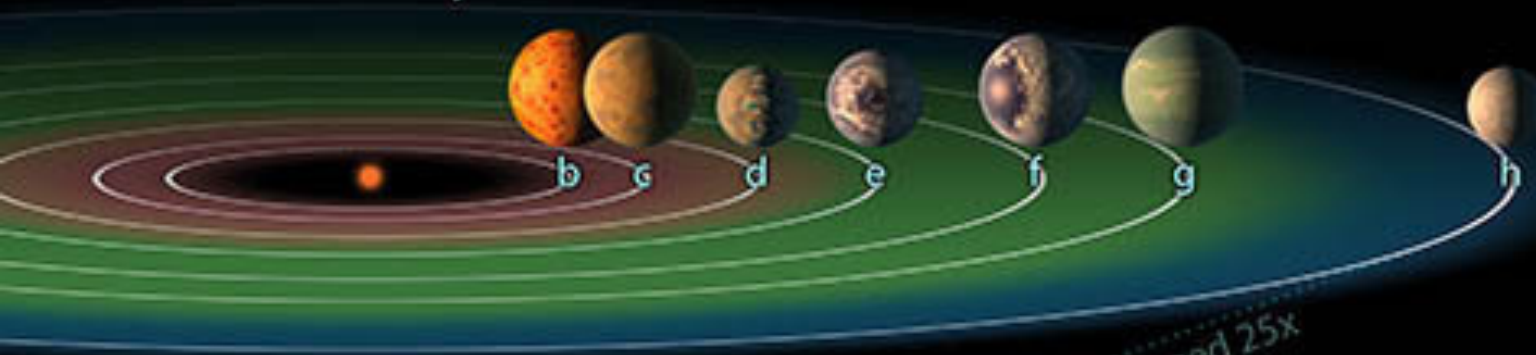
# Where to search for Habitable Worlds and for life?



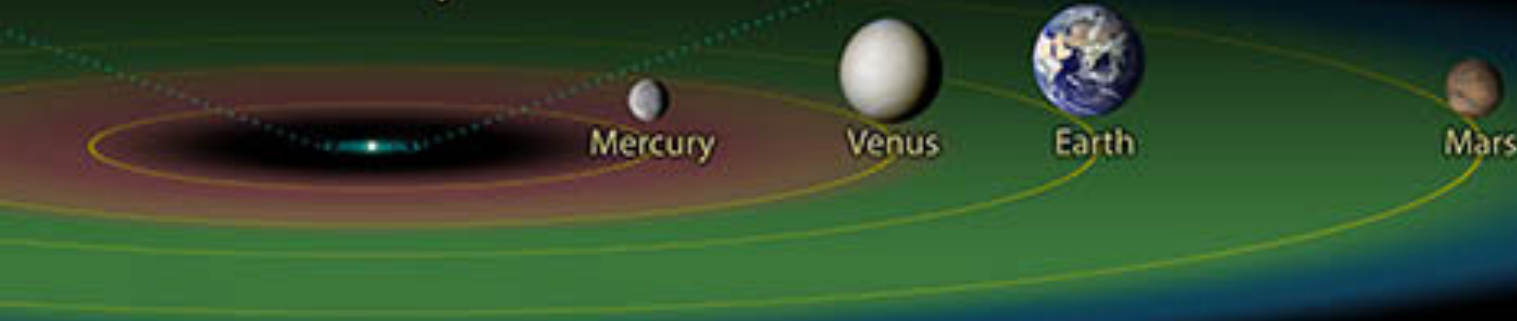
The Solar System: an ideal “habitability laboratory”

# The Trappist System

TRAPPIST-1 System



Inner Solar System



Enlarged 25x

# Studying Planetary Systems

## OVERARCHING SCIENCE GOAL

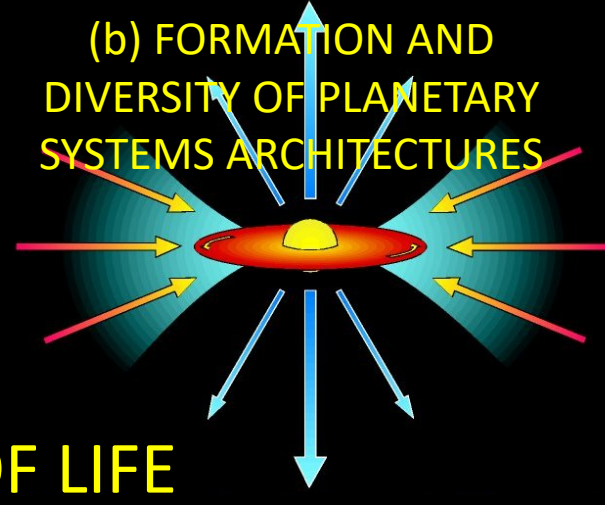
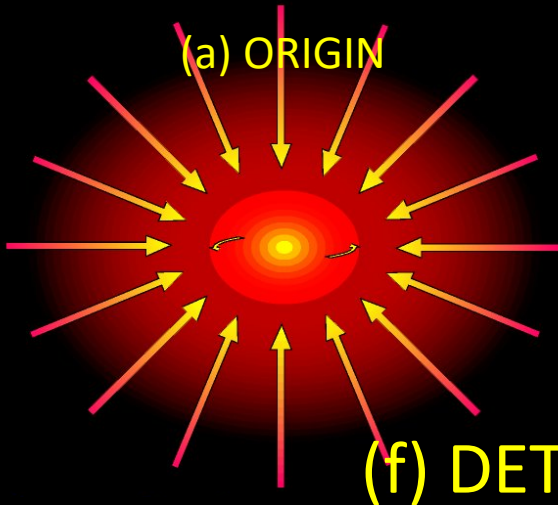
Study the formation and evolution processes leading to the growth of complexity, and ultimately to the possible emergence of life, through the diversity of planetary systems:

(1) the growth of molecular complexity, from the Interstellar medium (ISM) to planetary and moons environments;

(2) the growth of planetary environments complexity, and the conditions under which their evolutionary paths may lead them to become “habitable”.

# Studying Planetary Systems

## SIX MAJOR SCIENTIFIC QUESTIONS

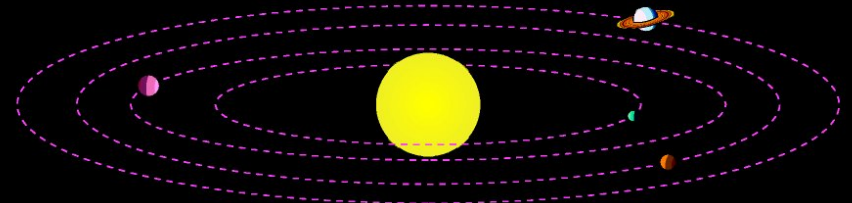


(f) DETECTION OF LIFE

(c) DIVERSITY OF OBJECTS



(d) HOW DO THEY WORK?



(e) EMERGENCE OF POTENTIAL HABITATS

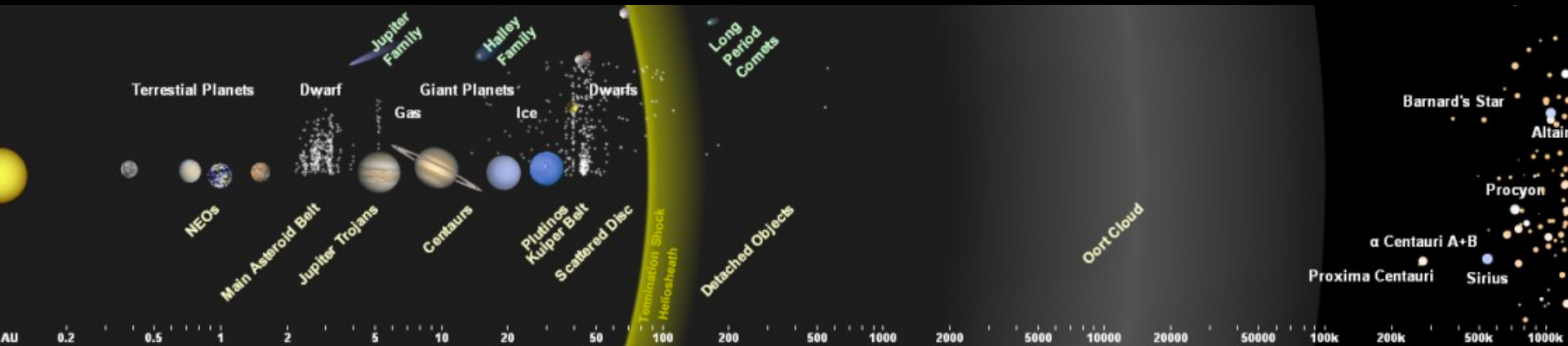
**Flying to the different  
provinces  
of the  
Solar System**

- 1. The Earth-Moon System**
- 2. Terrestrial planets**
- 3. Giant planets and their systems**
- 4. Small bodies**
- 5. Heliosphere, Solar System, ISM and beyond**



Thank you for your attention

# Solar System Exploration, today and tomorrow



ROBOTIC EXPLORATION

DETAILED COVERAGE BY  
SPACE-BASED TELESCOPES

SAMPLE RETURN

HUMAN  
EXPLORATION